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THE GREAT LAKES--NATURE'S OWN ENVIRONMENTAL LABORATORY

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This paper describes the Great Lakes, the worlds largest ecosystem and microlab, the history of man's interaction and pollution of it, and the subsequent cleanup ordered by law in recent decades and continuing into the present time.

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Environmental scientists take great pains in planning and executing their laboratory experiments. They are especially meticulous in designing experimental chambers, called microcosms, to simulate the reactions, fate, and effect of chemicals in aquatic systems. EPA and other water pollution scientists mimic nature in the experimental chambers as they carefully control temperature, light, and, finally, the addition of chemicals. They observe and record which organisms thrive, which ones die, how fast they grow, what abnormalities occur, and how the chemicals are distributed between sediment, water, and animal and plant life in the water-filled chamber. The information gained from this microcosm of the real world is tremendously helpful in acquiring scientific understanding of chemical interaction with nature.

Nature, on the other hand, provides the real world macrocosm; 15,000 years ago she began creating her own experiment on the North American continent, and in doing so provided today's scientist a larger laboratory in which to study and predict the impact of chemical pollutants on our waters and the life within them, and on the food chain and water supply that ultimately sustains human life.

This experiment began with immense sheets of ice, miles thick, slowly carving enormous aquaria from the earth as they advanced southward. After centuries of grinding and gnawing, these glaciers retreated, leaving in their wake five magnificent shining emeralds, the Laurentian Great Lakes.

This vast "macro-laboratory" includes the five main lakes, the connecting channels and hundreds of feeder tributaries, embayments and thousands of miles of shoreline. It provides the setting for a man and nature's collaborative experiment in physics, biology, geology, chemistry, limnology, and toxicology, and also in political science, economics, sociology, and law. The experimental design includes man first as the perturber of the natural environment, then as one of the perturbed species, and, finally, as the scientist and manager.

The results of nature's Great Lakes experiment reflect what is happening more slowly on a global scale and provide lessons in environmental science and management that are being applied, not only elsewhere in the United States, but in many parts of the world.

Nature stocked the Great Lakes with thousands of organisms, from microscopic bacteria and plankton to lake trout and huge sturgeon. This ecosystem maintained its natural equilibrium for centuries, supporting sparse populations of humans--first the native Americans and then the early European settlers. What human wastes entered the lakes a century or more ago were rapidly purified by natural processes. But when rich forests of the region began to be harvested to supply wood to the thriving metropolises of the east and south, the feeder streams and rivers became chocked with pulp and sediments, destroying important spawning areas. This was man's first serious interference (or "perturbation") with the region's ecosystems. Even today, remnants of that wood pulp may be coughed up when storms and waves churn up the bottom sediments where tons of sediment and wood debris flowed into the lakes years ago.

Few scientific observations of the Great Lakes were made in those days. No data documents the "initial condition" of nature's experiment. Only when

typhoid struck many Great Lakes towns in the early 1900s did significant studies of these waters begin. The studies resulted from the 1909 Boundary Waters Treaty between the United States and Canada and the establishment of the International Joint Commission (IJC), a binational body that continues to this day to negotiate international concerns about the Great Lakes and other common water systems.

These earliest studies, from 1913 to 1916, focused on the connecting channels--the Niagara River, Detroit River, St. Clair River, and Lake St. Clair--rather than the main lakes. The research centered on bacterial contamination from domestic sewage and found, for example, that the connecting channel flowing from Detroit into Lake Erie reversed its direction from time to time, bringing the raw sewage back into the drinking water intakes. As a result of the research and its recommended solutions, primary wastewater treatment was instituted, and wastes chlorinated. Typhoid was no longer a serious problem by the early 1920s.

This was the beginning of man's co-opting, so to speak, nature's laboratory as his own. Since the early twentieth century, pollutants of all kinds have flowed into the Great Lakes from growing industrial centers on or near their shores. Other pollutants have fallen from the atmosphere over the Lakes' vast surfaces, from runoff over millions of acres of agricultural land, or come from thousands of pleasure boats and ore and grain ships carrying their cargoes from as far west as Duluth to the Soo Canal and the St. Lawrence Seaway. All kinds of manufacturing plants have sent effluents into the rivers and bays and into the Lakes themselves; a number of nuclear power plants--in places like Manitowac, Wisconsin, and Zion, Illionis--discharge cooling waters into Lake Michigan. The situation became so bad that Lake Erie was declared dead or dying in the 1960s.

As all these elements were introduced into the Great Lakes "laboratory," the extent of research by American and Canadian scientists has grown and become much more sophisticated than the early sanitary surveys.

The first Conference on Great Lakes Research in July 1953, sponsored by the University of Michigan's Great Lakes Research Division, led to a formal organization of Great Lakes scientists, the International Association for Great Lakes Research, which today has over 1,000 members.

Larger research and monitoring programs followed in the wake of new and more serious environmental and public health concerns. When thousands of wildlife were being destroyed in the 1950s by continuous oil slicks in the Detroit River, duck hunters and early environmentalists were enraged and carried the oil-soaked carcasses to the steps of state capitols. Others lobbied furiously in Washington. The public was also alarmed when beaches were closed to swimming along the lake's shoreline, when windrows of dead fish lined the Chicago beaches, and when the Cuyahoga and Rouge Rivers actually caught fire.

The public demanded action since the survival of the Great Lakes ecosystem was clearly at stake. Under Public Law 660, anti-pollution enforcement and comprehensive studies were initiated. Important scientific data were collected and used as evidence in federal/state enforcement actions. The Great Lakes Illinois River Basin Project (GLIRBP) provided the first comprehensive water quality information for the Lakes and was used as a landmark decision on diversions through the Chicago Ship Canal. These research data remain in the EPA STORET for continuing analysis today and in the future.

At first, there was little need for sophisticated science in dealing with problems of gross pollution, i.e., grease, raw sewage, bacteria, dissolved

solids, and the like. Judges and enforcement panels were usually convinced by the photographic evidence and data summaries showing blatant violations of water quality norms. But as we became more aware of the different kinds of chemicals involved and their potential impact on not only the ecology but on human health, the 1970s saw tremendous research and surveillance efforts on the Great Lakes. Coordinated binational, interagency programs were developed to collect integrated data bases and develop mathematical models to help predict the future consequences of man's impact on the lakes and insights into optimal control strategies.

As the oil slicks were diminished as the result of better waste treatment and controls, some of the enforcement and research studies revealed a different, more ominous problem that had been overshadowed by previous and more obvious concerns. Eutrophication had accelerated proliferation of plant life in the lakes. Scientists found that the bottom waters of Lake Erie were void of oxygen for much of the summer. Shoreline residents complained of massive weed mats and floating green scum. Water treatment plant operators complained of clogged intake filters, and citizens objected to the musty taste and odors of drinking water.

Researchers using deep-water vessels were able to get water, sediment, and plant and other samples from all parts of the lake, and, as a result, to determine what was happening. They could evaluate the problem and determine the causes. In the Lake Erie situation, the waste nutrients were stimulating plant growth to the point where decaying vegetation was depleting the oxygen needed for fish and other helpful organisms to grow. The scientists were also able to relate the problem to the seasons of the year. The end result? Recommendations from mathematical predictions for the revival of the lake. Mathematical models predicted water quality improvements could be achieved if

inputs of phosphorus were reduced. All told, $14,000,000 was spent on this research which led to the billion dollar clean-up program and vast improvements in Lake Erie. This research also formed the basis on which studies on toxic substances were initiated.

Problems related to toxic substances are not a new issue for the Great Lakes. DDT was banned as a result of its confirmed impact on Lake Michigan wildlife feeding on Great Lakes fish (fish are amazing collectors of pollutants in the waters in which they live). In 1969, mercury was found to contaminate fish in Lake St. Clair and the Detroit River. Then it was discovered that mink reproduction was falling off as a result of PCB-contaminated salmon used as food.

Asbestos became the issue in Lake Superior when scientists found it to be a significantly dangerous component in the taconite tailings dumped into the lake by the Reserve Mining Company plant at Silver Bay, Minnesota. Those findings contributed to another landmark court decision, this one against Reserve Mining. And, most recently, Toxaphene, a pesticide used primarily in the southern United States, was banned on the basis of its presence in fish from an isolated lake on Isle Royale in the middle of Lake Superior just south of the Canadian border.

Today, over 800 chemicals have been identified by research scientists studying Great Lakes fish samples. Health advisories remain in effect in many parts of the lakes.

So far, a few studies have indicated that the lakes will recover if loadings of toxins are reduced. However, in other cases we do not know where they are coming from. For some chemicals, like Toxaphene, the immediate source is the atmosphere, but the ultimate sources are difficult to pinpoint. For others, the main source is the remaining reservoirs of contamination in

sediments that are slowly released to the water above them. Still other toxins come from contaminated landfills adjacent to the lakes or their tributaries, as in the case of the pollutants coming from the Grand Calumet basin near Gary, Indiana.

As minute as some of the loadings are, biomagnification may concentrate them up to a millionfold at the top of the food chain. It is not yet clear what real impact or risks many of these chemicals may present, either alone or in combination. There is some evidence that toxic substances may be preventing lake trout reproduction in Lake Michigan and may be retarding other ecosystem functions. There is strong evidence that tumorous fish and deformed fish larvae may also indicate contaminant effects.

Laboratory experiments provide insights, but the real environment tends to modify and complicate the results. In some cases, the chemicals can be modified within the environment, creating further compounds with unknown consequences.

These and other concerns coincided with increased national awareness of environmental degradation, the establishment of EPA in 1970, the signing of the U.S.-Canadian Great Lakes Water Quality Agreement in 1972, and passage of the Federal Water Pollution Control Act that same year. U.S. and Canadian researchers participated in the International Field Year on the Great Lakes (1972-73) on Lake Ontario. Earlier, in 1971, EPA established its research program on the Great Lakes at Grosse Ile, Michigan, and in 1978 created the Great Lakes National Program Office in Chicago. Much of EPA's research and surveillance in the Great Lakes region is funded or coordinated through the agency's Region 5 Office in Chicago.

Other laboratories and programs are being supported by the National Oceanic and Atmospheric Administration, the U.S. Fish and Wildlife Service, the Corps of Engineers, and various Canadian, state, and academic groups. Each agency and laboratory has a particular mission and regulatory program under which it operates.

Because no single agency or laboratory could possibly muster the resources and expertise necessary to meet the many scientific problems and data requirements of Great Lakes research, cooperation among all of these agencies, laboratories, and universities is and will remain essential.

Great Lakes scientists have discovered that much of the ecosystem detail can be simulated mathematically in time and space. This has not only been important for the Great Lakes, but for other large lakes around the world and for smaller U.S. and Canadian lakes. The same model formulations developed and verified for the Great Lakes have become useful tools throughout the world. Because of the Great Lakes experience, these predictive devices can be applied to other situations with greater confidence and much less data; such predictive models are being used, for example, in the Soviet Union, western Europe, and South America.

All of the U.S. and Canadian data have been archived in both Canadian and U.S. data bases. The EPA Large Lakes Research Station maintains this data base in STORET, in cooperation with the Great Lakes National Program Office in Chicago and the Canadian Centre for Inland Waters. It is available for researchers worldwide. These models and data are also providing the basis on which the toxic substance issue is now being addressed.

The problems are so many and complex that it is impossible to study all the chemicals in every area of the lakes at one time. Researchers have, therefore, chosen to study a few chemicals at a small number of locations very

thoroughly. The chemicals now under study include radionuclides and PCB's in Lake Michigan; PCB congeners and heavy metals in Monroe Harbor, Michigan; PCB mixtures and metals in Saginaw Bay, Michigan; and aromatic hydrocarbons in the nearshore waters of Lake Michigan.

Most recently, a coordinated study has been initiated for the Upper Great Lakes Connecting Channels which were the subject of the typhoid studies in 1913. This study, announced by former EPA Administrator, William Ruckelshaus in this address to the IJC in November 1983, is continuing nature's experiment, as scientists working in microlabs and the Great lakes macrolab carry on man's urgent efforts to keep his fresh waters clean and the food chain safe.